

Density-Aware Selection Tools

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ABSTRACT

In this paper we present selection tools that utilize pre-existing knowledge of the distribution of the underlying data to ease browsing and selection. These new data-aware selection tools include a slider, a range slider, and an improved lasso selection method. Standard models of these tools suffer from two common problems: poor subpixel data querying, and uniform visual representation of non-uniform data. We provide density-aware interactions to give users more efficient subpixel data querying and use embedded visualisations to better represent the data encoded by the tools. Through several controlled user studies, we find that our proposed density-aware slider outperforms standard alphasliders and default trackbars. We also find that a density-aware range slider and lasso selection outperform current state-of-the-art methods.

Author Keywords

Dynamic query, information visualization, slider, data selection, Alphaslider, lasso, range slider

ACM Classification Keywords

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General Terms

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INTRODUCTION

Dynamic queries provide easy to use, powerful and efficient tools and interfaces which allow users to rapidly and reversibly query data and uncover trends in the data being explored [1]. Currently, there are many tools available to users which benefit from the advantages of dynamic queries such as the slider, checkbox or button. The Alphaslider is a slider designed to query large lists of alphabetically sorted alphanumeric items [2]. The range slider is a slider which allows users to query a range of data items. This is a natural extension of the Alphaslider which only allows for single item querying. The lasso, a technique used to select multidimensional data, is an extension of the range slider where users lasso graphed or visualized data to

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highlight or zoom in on it.

The Alphaslider, range slider and the lasso technique suffer from two common problems. None of these tools have an awareness of the data they encode. This is especially important when the interfaces map more than one item to any pixel. Subpixel querying is a new problem because information density is ever increasing. With highly dense data more items are mapped to each pixel making efficient data selection increasingly difficult. The second problem is how each tool visualizes data in general and in high density areas. Many times there is no way for the user to know whether a given pixels maps to few or many items.

We propose density-aware selection tools. These tools are knowledgeable of the data they encode and use this information to simplify data querying. Our most efficient slider interface intelligently redistributes the items in densely packed pixels over a larger area and provides users with a list of nearby items giving the user a sense of location within the pixel. <Summarize range slider and lasso>. To solve the issue of data visualisation we used embedded visualisations such as those proposed by Willett et al [3]. These visualizations aid in estimation of the density of items in a given pixel.

Our results show that users can query significantly faster with density aware widgets when compared against the standard tools. **Interface X** allowed subjects to query significantly faster than both the Alphaslider and the default trackbar. Our proposed range slider outperforms standard range sliders while our lasso technique gave users no improvement for low and medium density information but showed large improvement over the current lasso technique for high density information.

This paper provides novel solutions to an aging problem and demonstrates that intelligent selection tools have the potential to improve upon the status quo. Although the proposed solutions perform more efficiently than previous standards there is still work to do in fine-tuning and possibly developing hybrid designs that take advantage of aged and novel ideas. In this paper we discuss will present the problem in greater detail, discuss related works and continue to describe the experimental design and results of our controlled user study. We will conclude the paper by discussing the implications of the research.

RELATED WORK

A significant amount of research has been done exploring dynamic query interfaces. Studies have shown that dynamic queries allow users to interactively and rapidly form queries [1] to explore datasets and discover trends [4]. FilmFinder by Ahlberg et al. [5] allowed users to search a database of movies through the use of several dynamic query tools. Users could explore the data to find that, for example, Western movies were more prevalent in the 1970s than in the 2000s. The Dynamic HomeFinder, an idea proposed by Williamson et al. allowed users to explore a real estate market to find homes satisfying their needs [6]. For example, the Dynamic HomeFinder allowed user to see how changing their acceptable price range would affect the available houses and their properties. The Dynamap [7] allowed users to explore trends in health statistics by overlaying health information on a map of the United States of America. Tools, such as the slider, were available to query different parameters to in order to explore the data. The paradigm we have built our experiments around is very similar to that of the FilmFinder where users can interact with and explore a database of movies. Users are given several dynamic query widgets which can be used to filter the movies and discover trends.

Standard dynamic query interfaces such as the slider, checkbox or button offer sufficient functionality in many cases; however, there have been many proposed improvements to these traditional interfaces. The Alphaslider [2] is a slider which allows users to quickly select a single item from an alphanumerically sorted list. The slider offers coarse and fine movement through a two tiled thumb and arrow buttons. The TrapezoidBox is a dynamic query tool which allows users to specify spatial proximity queries [8]. The TrapezoidBox allows users to specify queries such as: if the restaurant is within 300 meters then it can be 3 stars or higher; if the restaurant is with 500 meters then it must be rated 4 stars or higher; if the restaurant farther than 500 but no further than 1 kilometer then the restaurant must be rated 5 stars. Lanning et al [9] offer a novel way of interacting with and visualizing multidimensional data called MultiNav. The visual metaphor best associated with MultiNav is that of sliding rods where each rod (or slider) is linked to a dimension of data. Users can select value ranges along each rod to interact with the data. The Alphaslider is the baseline slider for our experiment. The Alphaslider was chosen for two purposes, namely it's efficiency and it's versatility. MultiNav was not an inspiration for our research because it is not suited to precise data selection in large data sets.

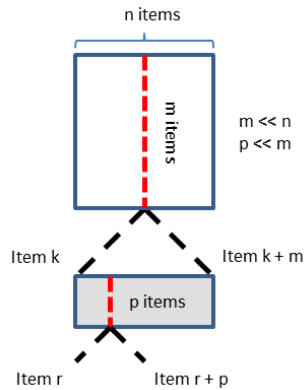
Very often there is a need for highly precise parameter selection. These situations arise in real-world scenarios

where the range of parameters vastly exceeds the available number of pixels. For example, an hour long movie filmed at 24 frames per second has 86400 frames. Using a slider to access individual frames for editing can be tedious. The Alphaslider [2] was designed with situations such as this in mind. The PVSlider [10] and FineSlider [11] both aim to improve upon the Alphaslider. The PVSlider uses a popup vernier to give users sub-pixel-pitch control and sub-pixel visualization. The FineSlider uses an elastic band metaphor to give users more intuitive control over scrolling speed and precision where a longer elastic band correlates to faster scrolling and a shorter band correlates to more precise and deliberate item selection. The Zlider proposed by Ramos et al takes advantage of pressure input to fluidly change from coarse to fine granularity and shift granularity control from the system to the user [12]. Aspects of the PVSlider and FineSlider overlap with the purpose of this research but they were not given priority over the Alphaslider for several purposes: 1) The FineSlider, as shown in the experiment by Ayatsuka et al in [10] performed worse than the Alphaslider and was less favoured by the participants. 2) The PVSlider, although marginally faster, gives subpixel visual feedback which is reliant on monodensity information across the slider which is not required by the Alphaslider. The Zlider was not chosen because there is no way for users to give pressure input to our system.

DESIGNING OF MULTI-ITEM PIXEL ASSIGNMENT

Mapping multiple items to a single pixel and giving users quick access to each item remains an ever-present problem. The Alphaslider gets around this issue by giving users list based movement where the user navigates the list of items encoded by the slider through coarse or fine grained dragging. Coarse dragging lets the user skip through the list 10 items at a time while fine grained dragging lets the user move through the list 1 item at a time. This causes a problem to arise when multiple lists are present of different densities; a slider encoding 10 000 items will feel heavier than a list encoding 1 000 items causing difficulty for the user in predicting how quickly they need to drag the slider. The Alphaslider's querying method gives no visual feedback when the items per pixel exceeds the coarse grained movement value making highly dense data even more confusing.

Subpixel visual feedback is also an issue intricately associated with the Alphaslider. This problem was identified by Ayatsuka et al and they attempted to rectify it. However, their solution lacks the ability to dynamically adapt to the encoded data. The popup vernier in the PVSlider requires that the developer be explicitly aware of the information to give the slider appropriate scales for the popup vernier.



Approaching this problem with multi-level querying in mind can solve the above issues. By giving the user multi-level querying the issue of slider “weight” is solved because the slider’s movement is pixel based instead of list based. Items per pixel becomes a non issue in terms of visual feedback because coarse querying is pixel based instead of item based. Subpixel querying is partially solved because items mapped in a single pixel are instead mapped along the width of slider which can be individually selected. This solution requires refinement. We will present our final solution later in the paper.

EXPERIMENTAL DESIGN

Introduction

An experiment was conducted to compare different designs of density aware sliders against the Alphaslider and the standard Trackbar found in WinForms.

Apparatus

The interfaces used in the experiment were built using Visual Studio 2010 Professional. A 23.5 inch Dell monitor with a resolution of 1920x1080 pixels with a standard 3 button mouse was used. Query results were displayed in Microsoft Sans Serif with a font size of 8.25 while query targets were displayed in Microsoft Sans Serif with a font size of twelve. An Intel i5-2400 CPU with a clock speed of 3.1 GHz was used along with 4 GB of RAM.

Interfaces

A total of 7 different sliders were used in the experiment (Figures 1 through 6). In all cases the text output was RSVP and was displayed under the slider. Between searches subjects had to press a “Start” button indicating they were ready and upon completion of the search the subject had to press a “Confirm” button indicating they have completed the search. **This is going to be changed. Instead of clicking on buttons the user will toggle states by pressing the space bar.**

Alphaslider

The Alphaslider (Figure 1) has four navigation techniques. Users can jump directly to an item in the list by clicking anywhere in the bounded area above the letters. Users can navigate through the list at a rate of ten items per mouse movement by clicking in the top tile of the slider thumb and dragging. Users can also navigate one item at a time either by clicking on the arrows at the ends of the slider or by clicking in the bottom tile of the slider thumb and dragging.

ActiveArea Slider

The ActiveArea Slider (Figure 3) allows users to navigate by clicking on and dragging the slider thumb, by clicking on and dragging the secondary red slider or by pressing the left or right arrow keys on the keyboard. The main slider has a variable size which changes based on the density of information of the pixel it queries. Dragging the secondary red slider allows users to query other items found in the pixel being queried by main slider. The red slider is bound by the edges of the main slider.

Hypotheses

This paper is primarily concerned with designing the most efficient slider. While accuracy is an important factor in designing a slider that attribute falls largely upon the user. Because of this speed is the most significant factor to measure. The speed with which a user locates an item is largely dependent on total mouse movement. For each of the sliders there is a period of querying where the user approximates the area of the target and a period of querying where the user does fine adjustments to acquire the target. Based on this assumption the following hypotheses can be made:

- 1) The ActiveList slider will perform the best because it does the best job breaking the query into multiple levels
- 2) All of our sliders will outperform the Alphaslider because they give the user better control and visual feedback

Experiment Variables

Independent Variables

- i) Type of interface
 - a. Alphaslider
 - b. ActiveArea slider
 - c. List slider
 - d. ActiveList slider
- ii) Target density
 - a. High
 - b. Medium
 - c. Low
- iii) Data size

- a. Small
- b. Medium
- c. Large

Dependent Variables

- i) Speed of acquisition
- ii) Error rate
- iii) Subjective satisfaction

Tasks – rewrite this part

Subjects completed three trials for each permutation of the independent variables. Each target was randomly generated at runtime. To mitigate learning effects new data was randomly selected upon interface change. With each new task the thumb was brought to the beginning of the slider.

Participants

Procedures

A pilot study was first done to weed out poorly designed and inefficient interfaces. Prior to the timed trials the subjects were given five minutes to familiarize themselves with each interface while reading interface specific instructions and ask questions. During the timed trial the subjects were not allowed to ask questions. Upon completion of the experiment the subjects were asked to fill out a questionnaire.

RESULTS

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CONCLUSION

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ACKNOWLEDGMENTS

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